



space administration



# ExMC'S STRATEGY AND APPROACH FOR ACHIEVING PROGRESSIVELY EARTH INDEPENDENT MEDICAL OPERATIONS FOR NASA HUMAN SPACEFLIGHT EXPLORATION MISSIONS

**Kris Lehnhardt, MD**  
Element Scientist, ExMC

**Shean Phelps, MD, MPH**  
Associate Scientist, ExMC

**Benjamin Easter, MD, MBA**  
Acting Element Scientist, ExMC

**Nancy Fleming**  
Element Manager, ExMC

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**“Expanding the Boundaries of Space Medicine and Technology”**

- Risk Title:** Risk of Adverse Health Outcomes & Decrements in Performance due to Medical Conditions that occur In Mission
- Risk Statement:** Given that medical conditions will occur during human spaceflight missions, there is a possibility of adverse health outcomes & decrements in performance during these missions and for long term health.
- What is required for the Medical Risk to be acceptable:** High confidence that astronauts can accomplish mission medical tasks in a progressively autonomous fashion

DRM Categories	Mission Type and Duration	Operations		Long-Term Health	
		LxC	Risk Disposition *	LxC	Risk Disposition *
Low Earth Orbit	Short (<30 days)	3x2	Accepted	3x2	Accepted
	Long (30 days-1 year)	4x2	Accepted	4x2	Accepted
Lunar Orbital	Short (<30 days)	4x2	Accepted	3x2	Accepted
	Long (30 days-1 year)	5x3	Requires Mitigation	4x2	Requires Characterization
Lunar Orbital + Surface	Short (<30 days)	4x3	Requires Characterization	4x2	Requires Characterization
	Long (30 days-1 year)	5x4	Requires Mitigation	4x4	Requires Characterization
Mars	Preparatory (<1 year)	5x4	Requires Mitigation	4x4	Requires Characterization
	Mars Planetary (730-1224 days)	5x5	Requires Mitigation	5x4	Requires Characterization

DRM = design reference mission

L x C = likelihood and consequence



# MEDICAL RISK INCREASES WITH DISTANCE FROM EARTH



International Space Station

Gateway

Lunar Surface

Mars Transit

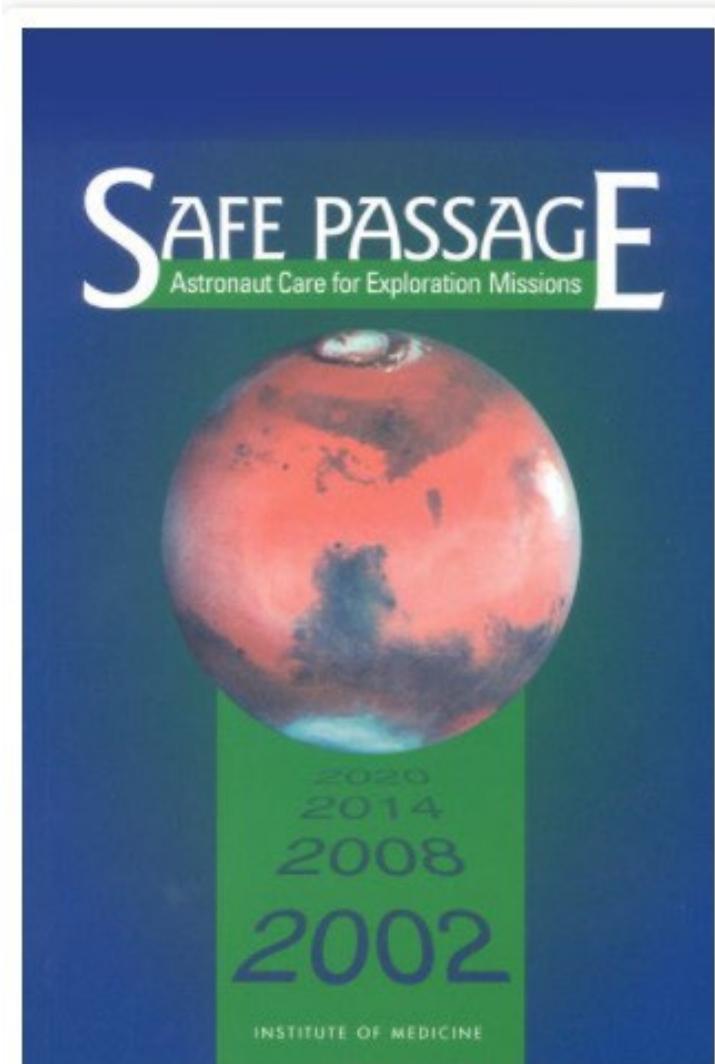
## CURRENT STATE

- 180-day to 360-day mission duration
- Strong consumables resupply
- Real-time communications
- Regular sample returns to Earth
- Emergency evacuations possible
- Relatively large internal volume
- Limited onboard medical care (Earth-reliant)

## EXPLORATION CLASS MISSION

- 650-day to > 900-day mission duration
- Zero consumables resupply
- No real-time communications + blackouts
- No sample returns to Earth
- No evacuations possible
- (Likely) much smaller internal volume
- Expanded onboard medical care (crew/vehicle-reliant)

# Why does the Medical Risk matter for exploration missions?



## Human Exploration of Mars: Preliminary Lists of Crew Tasks



## Autonomous Medical Care for Exploration Class Space Missions

Hamilton, Douglas MD, PhD; Smart, Kieran MD, MPH; Melton, Shannon BS; Polk, James D. DO; Johnson-Throop, Kathy PhD

[Author Information](#) 

The Journal of  
**Trauma and  
Acute Care Surgery**

The Journal of Trauma: Injury, Infection, and Critical Care: April 2008 - Volume 64 - Issue 4 - p S354-S363

doi: 10.1097/TA.0b013e31816c005d

# Earth-Independent Medical Operations (EIMO)



## Medical Training

NASA/TM-2014-217384



### **Identification of Medical Training Methods for Exploration Missions**

*Rebecca S. Blue, MD, MPH  
Laura M. Bridge, MD  
Natacha G. Chough, MD  
James Cushman, MD, MPH  
Muska Khpal, MBBS  
Sharmi Watkins, MD, MPH*

## In-situ Medication Analysis



# Previous ExMC Work in Support of EIMO

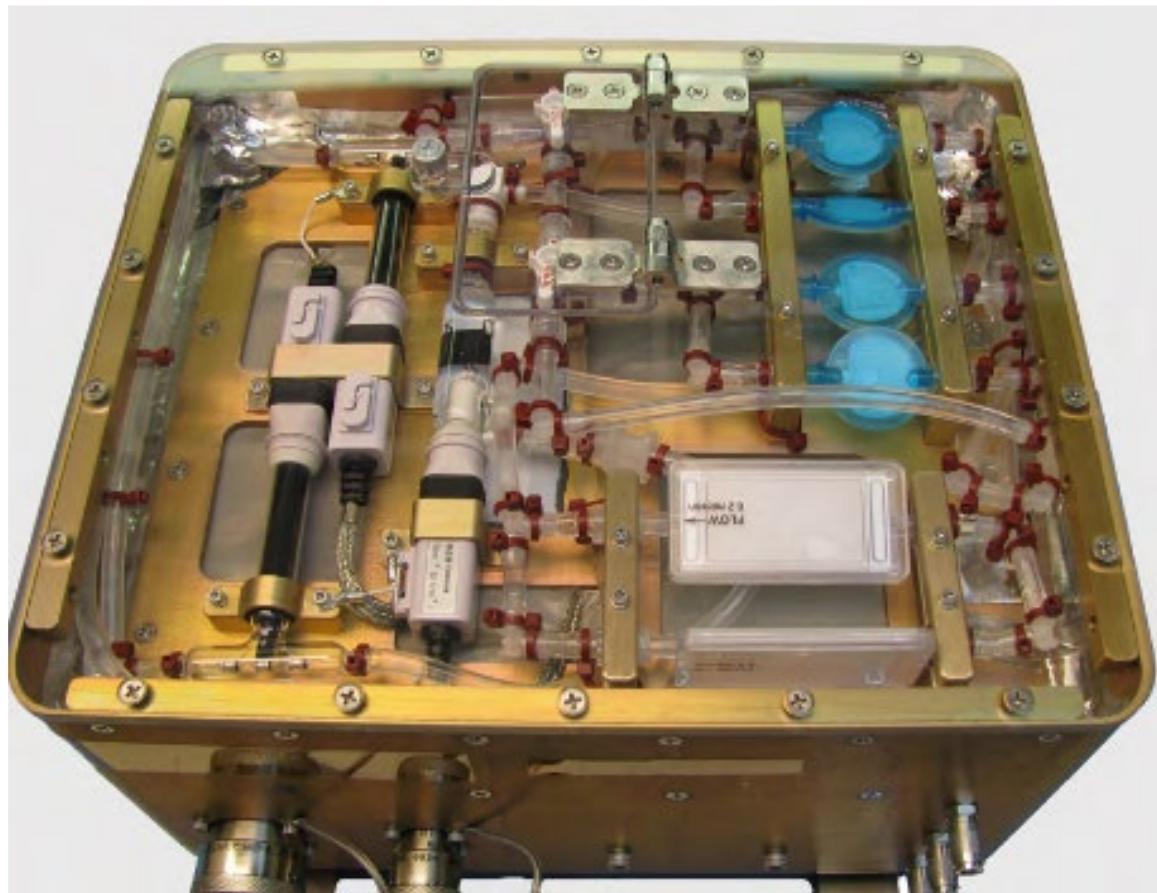
## Procedural Guidance



## In-situ Diagnostics



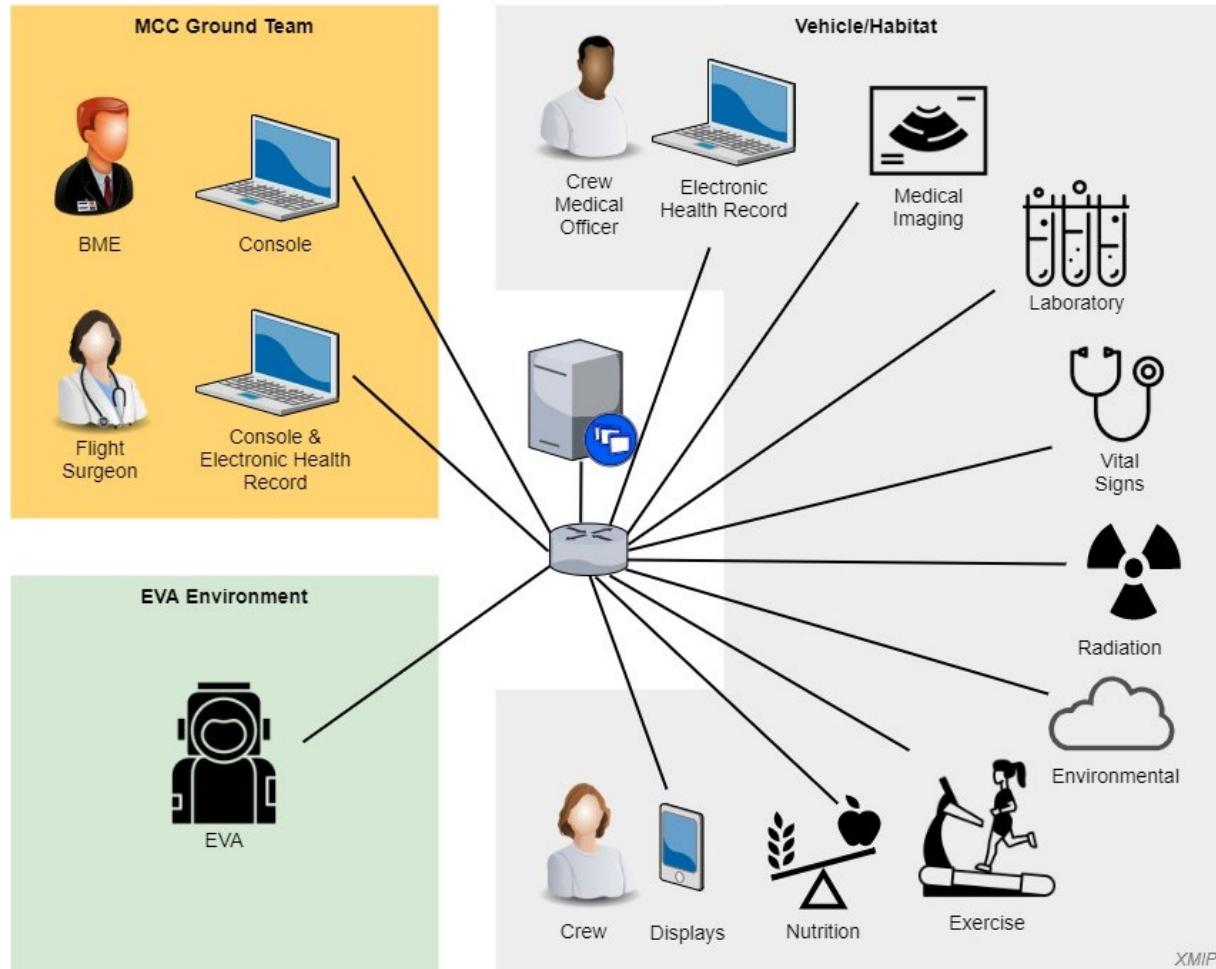
## In-situ IV Fluid Generation



## Inventory Management/Consumables Tracking



## Integrated Data Architecture



## Multifunctional Medical Devices

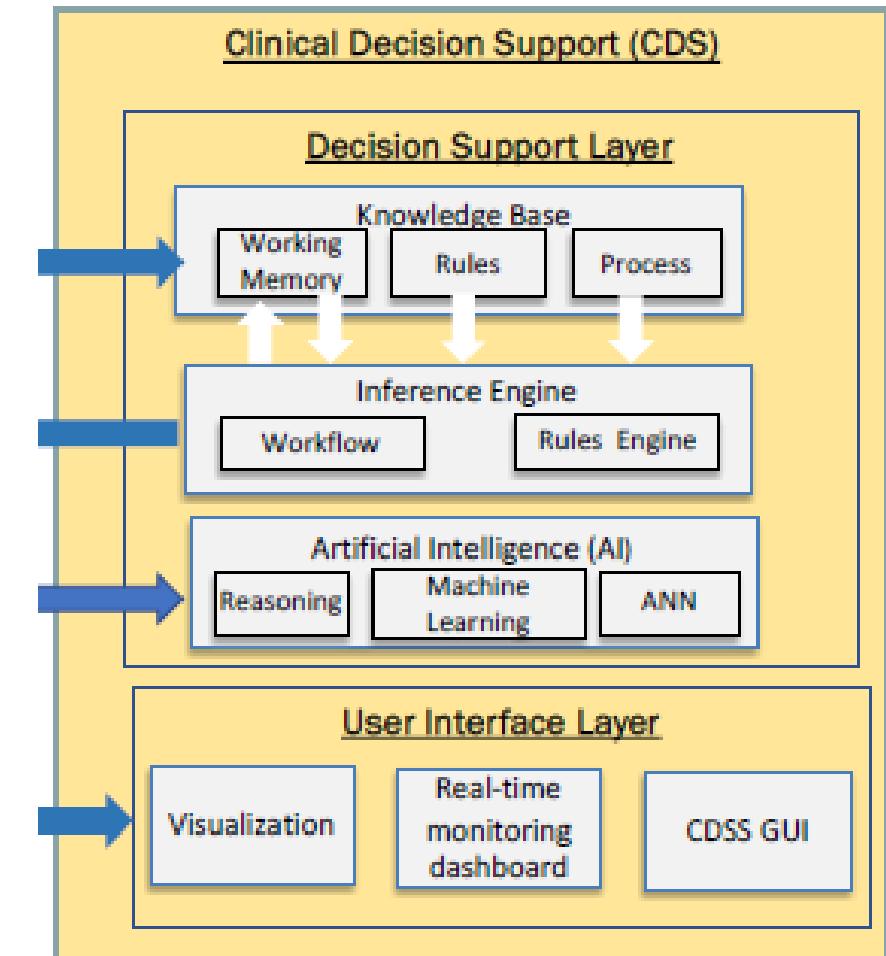


# Current EIMO ExMC Work

## Expanded In-situ Diagnostics



## Clinical Decision Support





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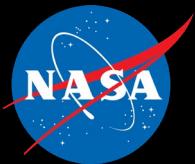


# What's Next?

**“Expanding the Boundaries of Space Medicine and Technology”**

- Identify stakeholders and ascertain high-level EIMO needs, goals, and objectives
- Solicit input from broader human spaceflight community
- Develop an EIMO Concept of Operations – outlines the vision for autonomous exploration medical care
- Share EIMO vision internally and externally to NASA

- Build tactical plan based on iteration and demonstration to progressively increase astronaut self-reliance for medical care
- Maximize utility of ground testbeds and analog environments (including ISS)
- Targets: Mars Transit Habitat, Artemis Base Camp
- Ultimate goal = astronauts taking care of astronauts, far from home, when they are healthy and when they are sick or injured, with Earth support as needed



# QUESTIONS?



Email: [kris.lehnhardt@nasa.gov](mailto:kris.lehnhardt@nasa.gov)